Masterpieces to Mathematics:

Using Art to Teach Fraction, Decimal, and Percent Equivalents

Christopher Scaptura, Jennifer Suh, and Greg Mahaffey

Developing visual models of rational numbers is critical in building an understanding of multiple and equivalent forms of rational numbers and the relationship among fractions, decimals, and percents. Historically, middle school students have had difficulty with rational numbers for a variety of reasons. Sowder and Schappelle (1995) state that middle school students spend little time with problems that relate fraction and decimal numbers. Often, fractions and decimals are taught separately without providing students the opportunity to make the connection, which stunts their ability to fully understand rational numbers. In addition, the National Research Council (NRC 2001) reports that "rational numbers are more complex than whole numbers, in part because they are represented in several ways" (p. 231) (e.g., common fractions and decimal fractions) and used in many ways (e.g., as parts of regions and sets, as ratios, as quotients).

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These topics also present a challenge for middle school students because they are likely to have few out-of-school experiences with rational numbers. Therefore, the NRC recommends that "teachers play a more active and direct role in providing relevant experiences to enhance students' informal understanding and in helping them elaborate their informal understanding into a more formal network of concepts and procedures" (NRC 2001, p. 231). This article shares how students created their own Op Art (optical art), which was inspired by Ellsworth Kelly, and how they connected that work of art to rational numbers. By identifying colored portions of a grid, the students recognized fraction, decimal, and percent breakdowns of their own designs. Through visual and mathematical representations of rational numbers, they learned mathematics through the lens of an artist.

CONNECTING MATHEMATICS WITH THE ART

While searching for an interesting and effective way to help my sixth-grade students at Westlawn Elementary School in Falls Church, Virginia, grasp the concept of decimal, fraction, and percent equivalents, sixth-grade mathematics teacher Greg Mahaffey and I discussed several lessons using the 100 square grid as a way to illustrate portions of a whole. Squares on a grid immediately made me think of American artist Ellsworth Kelly, a twentieth-century painter and sculptor who is recognized and admired for his contributions to abstract art. Like many other American artists in the 1950s, Kelly experimented with color-field painting. Kelly used a grid system, placing a variety of warm and cool colors against one another to create optical effects on the canvas. One particular painting from 1951, titled *Colors for a Large Wall*, hangs in the Metropolitan Museum of Art in New York. He combined 64 solid-colored painted squares into a grid. This painting inspired me to experiment with a similar idea with my class.

With help from Jennifer Suh and Greg Mahaffey, I developed a lesson based on a grid. Students constructed their own artwork by gluing small colored paper squares on a grid.

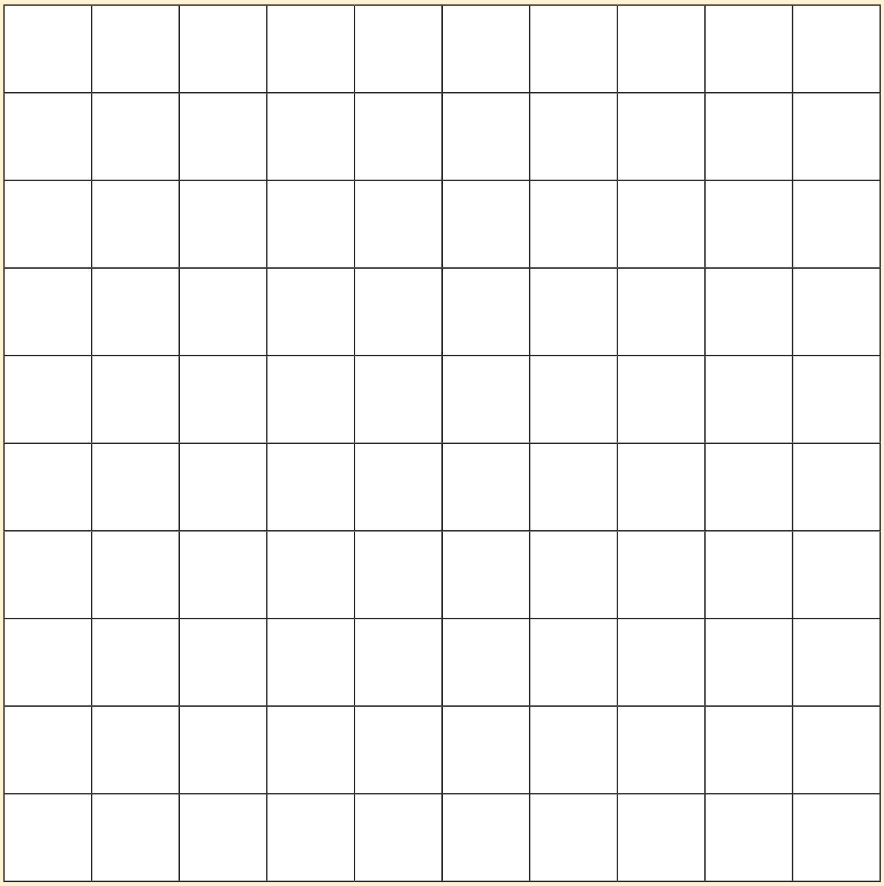
THE TASK

In preparing for the lesson, I used a grid of 100 squares so that students could clearly visualize and determine the decimal form (0.01 for each square) for the amount of each color used. (See worksheet 1 in **fig. 1**.) Students could then calculate their fraction and percent equivalents. Each student was required to use at least three colors of squares. Squares left blank could be counted as white. I asked students to choose from a total of six different colors but ultimately left the design of the artwork to them.

Since I taught this lesson to four mathematics sections at the school, I had to cut 7200 one-inch paper squares. (This would be an excellent activity for a willing parent volunteer.) The cut paper squares had more concentrated color than could be achieved with pencil or crayon, and the task of gluing required less time and dexterity than drawing blocks of color.

Before the students began their artwork, I introduced the task with a minilesson on the relationship between art and mathematics. These two subjects are not often used in combination, so I provided concrete examples of artists' work that demonstrated this connection. I created a brief slide show of color-field and op-art images by artists like Piet Mondrian, Victor Vasarely, Ellsworth Kelly, Kenneth Noland, and Frank Stella. As we viewed these works of art, most students could see that measurement

Fig. 1 Worksheet 1 that was used in class



NAME ____________________

Color	Number	Fraction	Decimal	Percent

and subdivision of the canvas were hallmarks of this form of abstract expressionism. I allowed the slide show to run continually as a source of inspiration for students while they worked on their pieces.

STUDENTS' REPRESENTATIONS AND MATHEMATICAL THINKING

Students were given twenty minutes to design and glue their squares to the background paper. I created the background using pencil and paper and copied the 10 in. × 10 in. grids onto ledger-sized sheets. These larger sheets of paper allowed space at the bottom of the page for a small table (see the table in **fig. 1**), divided into five columns for the categories of color, number, fraction, decimal, and percent. After completing their designs, some students counted the number of squares of each color and computed the unreduced fraction equivalent based on the total number of squares (*x*/100 for each color). These students then computed the decimal and percent equivalents. When changing from a fraction to decimal and percent equivalents, students were able to refer to their grid and their counted number of colored squares as a reminder of the equivalent nature of these numbers. Other students started by finding the decimal expression for each color, as explained earlier. As the students finished their computations, I walked around the room and questioned them about their design, mathematical reasoning, and strategies for checking to see that their calculations were correct. I reminded the class that all values in the number and percent columns should add to 100 and that those in the fraction and decimal columns should add to 1. For students who seemed unsure about the fraction to decimal conversion, I suggested that they think in terms of money, with the 100 grid representing a dollar, and the decimal representing the equivalent in cents. A few students discovered errors, but most completed the calculations without much trouble or teacher assistance. The table at the bottom of the page was used to assess students' understanding of the concept.

Fig. 2 Roberto's design used "neat" numbers.

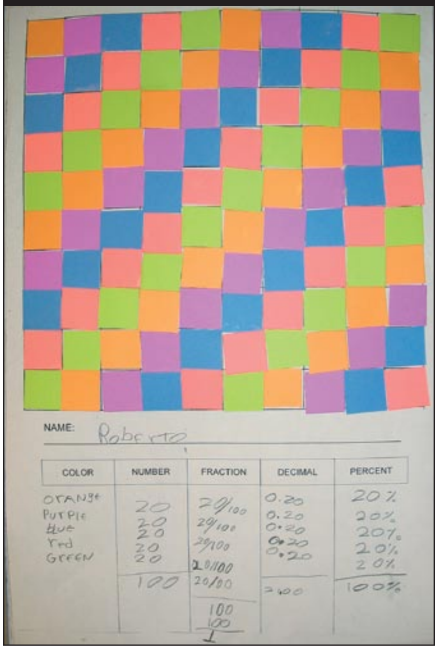
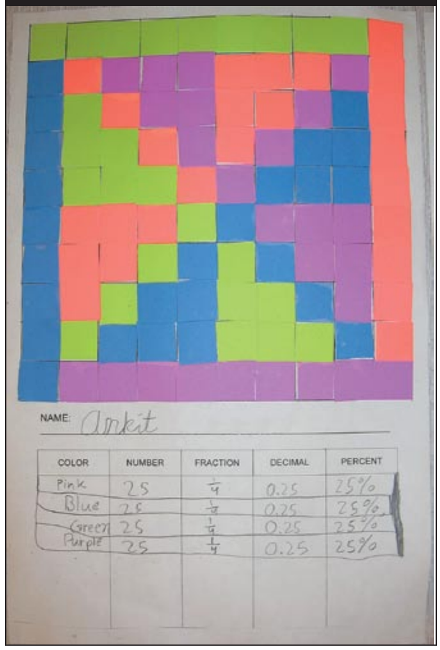


Fig. 3 Ankit produced an intricate design with four colors.



Some students worked methodically in designing a symmetrical pattern with a distinct color and design (see **figs. 2, 3,** and **4)**. Others chose an abstract form by randomly gluing the squares on the grid (see **fig. 5**). Some students personalized their art by designing patterns to represent one of their initials or a smiley face (see **fig. 6**).

When calculating the total number of squares used by different colors, the students who used a color or symmetrical pattern found a numerical-pattern shortcut. For example, Roberto's design used five colors: orange, purple, blue, red, and green (see **fig. 2**). His orderly pattern resulted in "neat numbers" (i.e., 20 squares = 20/100, or 1/5, 0.20, and 20%). He added each column to check his work. Ankit also used an equal number of squares of each color for his intricate design: pink, blue, green, and purple (see **fig. 3**). Therefore, in his table, he had 25 squares for each color that equaled 25/100, or 1/4, 25%, and 0.25 of the total grid.

Some students wrote the decimal fractions first, then listed other equivalent fractions (i.e., 36 squares = 36/100 = 9/25, or 4 squares = 0.04 and 4/100 = 1/25). (See **fig. 6**.)

The students who chose to create a more random design found that they needed to be more careful when counting the number of squares for each color. In fact, some students realized that their calculations were incorrect when the total values in a column did not add to 100 percent or 1. They knew that they needed to recount the number of squares for each color. This built-in, self-checking format allowed students to verify their answer without help from the teacher.

Many of my students participate in the English for Speakers of Other Languages (ESOL) program, and a few speak very limited English. This activity seemed to benefit these students by allowing them to work on a visual project and a student-created manipulative. It helped them communicate and in so doing build confidence in their understanding of the math-

ematics concepts of fractions, decimal, and percent. In fact, the cooperating teacher and I overheard a conversation in Spanish where one student was explaining to his classmate what each category represented on the table. He was saying words like *por ciento* and *fraccion*. We capitalized on that teachable moment to discuss the etymology of the word *per cent*. In the 1400s, the word *per cento* was used to describe a percent, or per one hundred. Today, we abbreviate it to the symbol %.

For a limited number of students who clearly had an easy grasp of this concept, we presented them with a more difficult task by asking them to eliminate the outside row of squares, thus limiting the grid to 64 squares. The students who took this challenge had more difficulty determining decimal and percent equivalents (see **fig. 5**). Because the focus of this lesson was on equivalents, I allowed students to use calculators, when needed, to determine percents. Kevin took the challenge and used five colors randomly. By using the 8 in. × 8 in. grid, Kevin was forced to work with fractions and decimals that were not "neat." For example, for the blue and purple squares, he wrote 11/64. By using the calculator, he was able to experiment with numbers. Because of the limited time and the difficulty of the 64-square grid, Kevin could not fully check his work. Had he done so, he would have found that the decimal column did not add to 1 and the percent column did not add to 100.

To reinforce the relationship among decimals, fractions, and percents, I also created a sheet for students to complete as homework (see worksheet 2 in **fig. 7**). Unlike the class project, this homework sheet did not include the 100 grid. Students were asked to fill in a table of equivalents based on one or more numbers from each set. I included tenths, fifths, and quarters on the sheet. Students found the missing pieces easy to determine without using a calculator. For most of the numbers, I tried to stay with common values that they might encounter. I also added an additional column labeled "equivalent dollar amount" to reinforce the fact that our monetary system is based on 100 and correlates to the 100 grid that they had used in class. Students demonstrated a high rate of success on this homework task.

When the students' artwork was completed and checked, I displayed the designs in the hallway outside of the mathematics room. The grids made a colorful addition to our school as well as reinforced the students' understanding of the relationship among rational numbers.

CONCLUDING REMARKS

This activity helped build students' understanding of the relationships among rational numbers by seeing how fractions, decimals, and percents are related. It also stimulated their interest in Op Art and allowed them to express themselves artistically. Students engaged in activities that allowed them to model rational numbers in various representational systems: pictorially, verbally, symbolically with numbers, and with physical manipulatives using the grid and color squares. Lesh, Post, and Behr (1987) state that students gain a deeper understanding of a concept when they can identify and model a mathematical concept in various representational

Fig. 4 Rocio's numbers required several calculations.

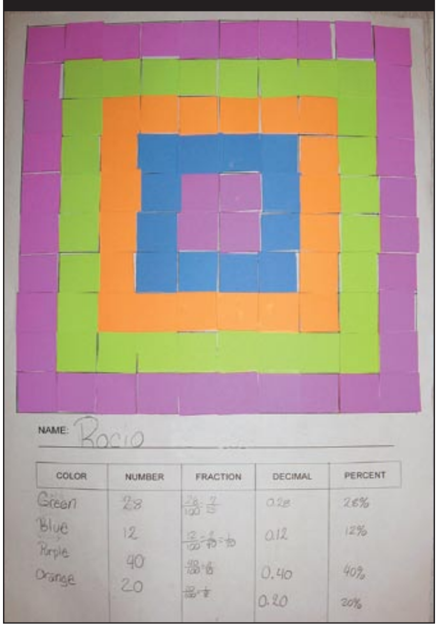


Fig. 5 Kevin took on the challenge of the 64 square.

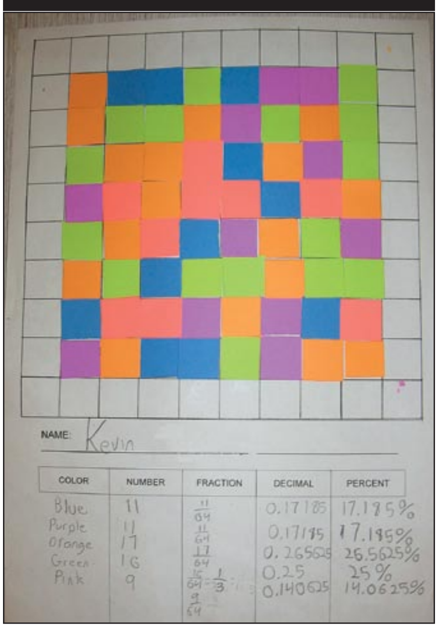


Fig. 6 Quoc obviously found joy in this project.

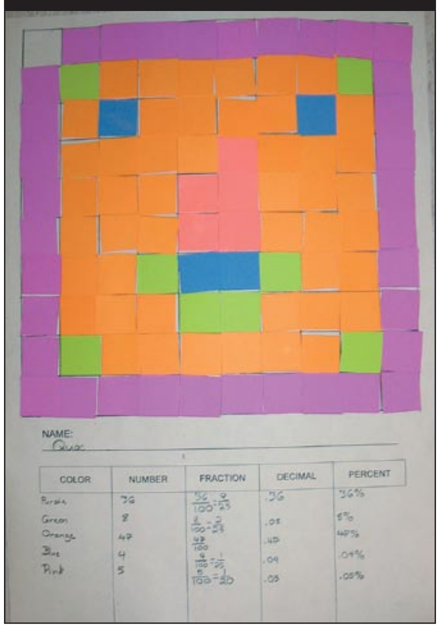


Fig. 7 Worksheet 2 was completed by students.

NAME ______________________ DATE _____________

Fill in the missing percent, decimal, and/or fraction for each of the following:

	Number of Squares out of 100	Fraction	Decimal	Percent	Equivalent Dollar Amount
1	75	3/4	0.75	75%	$0.75
2		1/5	0.2		
3	30		0.3		
4		12/25		48%	
5	60				
6				37%	
7			0.56		
8	44				
9		23/25			
10		7/10			
11				91%	

systems and have the flexibility to move from one representational system to another. *Principles and Standards for School Mathematics* (NCTM 2000) encourages students to represent their mathematical ideas in ways that make sense to them, even if those representations are not conventional. By moving from one representational system to another, students exercised flexibility in their thinking and gained a deeper understanding of a concept.

The lesson was particularly useful in addressing the needs of the students at Westlawn Elementary School. A large percent of our students are second language learners or are living in poverty. We must address the lack of background knowledge that some of these students bring with them to the classroom. This is especially true in regard to vocabulary and visual memory. Many visual and manipulative models can be employed to build conceptual understanding of decimals and fractions. The power of embedding art into the model is that students consider the creation of artwork as the end goal and own the learning as a means to an end. Thus students build visual knowledge as well as create visual models in the process of creating artwork. In addition to the embedded learning, students feel greater ownership over a model that they have created themselves, and this engenders long-term memories that can be accessed throughout the school year and beyond. Students at Westlawn have expanded their models past equivalent representations of rational numbers to include greater understanding of ratios and proportion.

The open nature of the task allows teachers to tailor it to lower or upper grades and differentiate within classes by altering the number of squares in the grid. For younger students, the table activity could be limited to counting the number of squares of each color and expressing these values as fractions. The same method could be used with decimals. Older or more advanced students could work with a grid of 64, 121, or even 1000 squares. As with the number of grid squares, the teacher could also increase or decrease the number of colors available or required when creating the art. To save money, smaller scale grids could be used and colored pencils could replace paper squares.

Students usually have fewer out-of-school experiences with rational numbers than with whole numbers, making it necessary for teachers to provide relevant experiences to enhance students' informal understanding of fractions, decimals, and percents. Although combining great works of art with rational numbers may not seem like an obvious approach to teaching mathematics, the designs of masters like Ellsworth Kelly provide students with concrete examples of how two subjects as diverse as art and mathematics connect and work together in the world beyond the classroom.

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